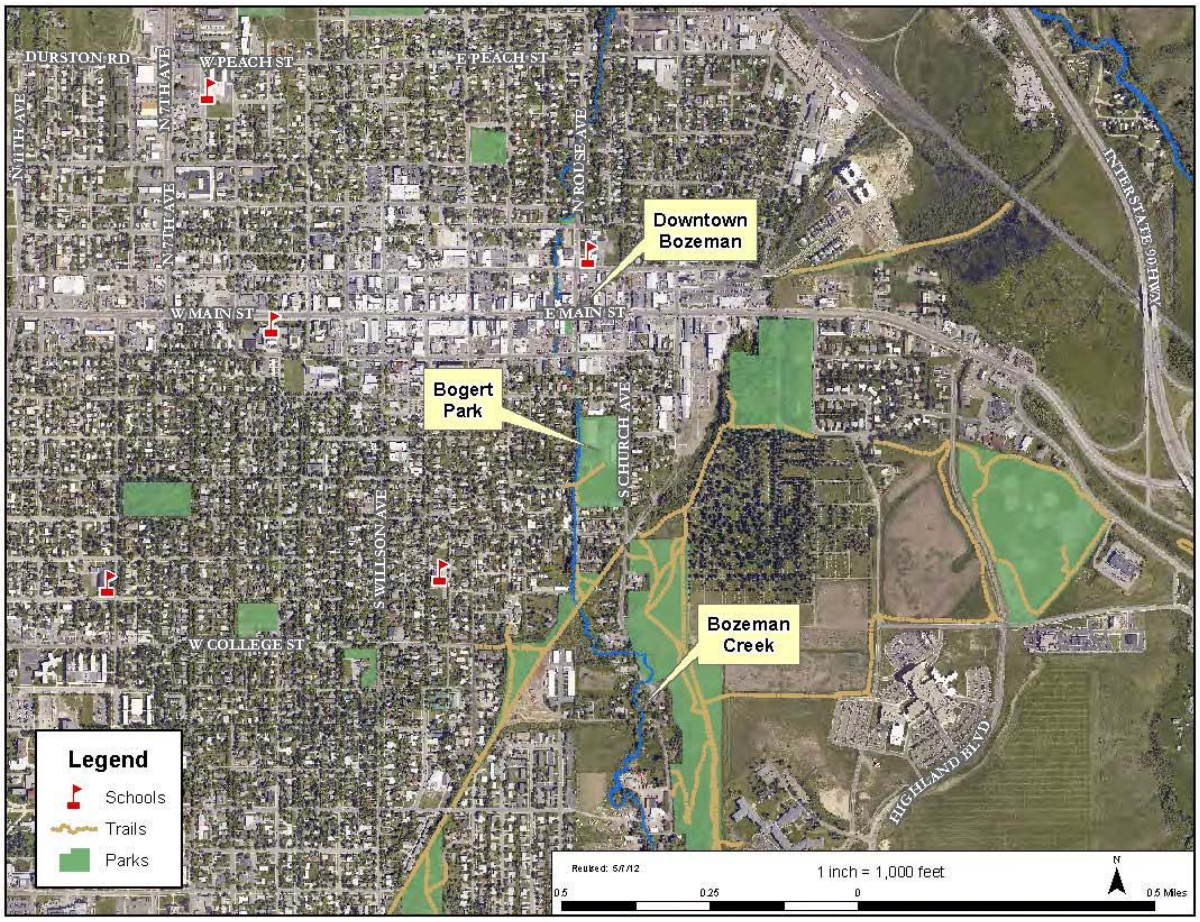
FUTURE FISHERIES IMPROVEMENT PROGRAM

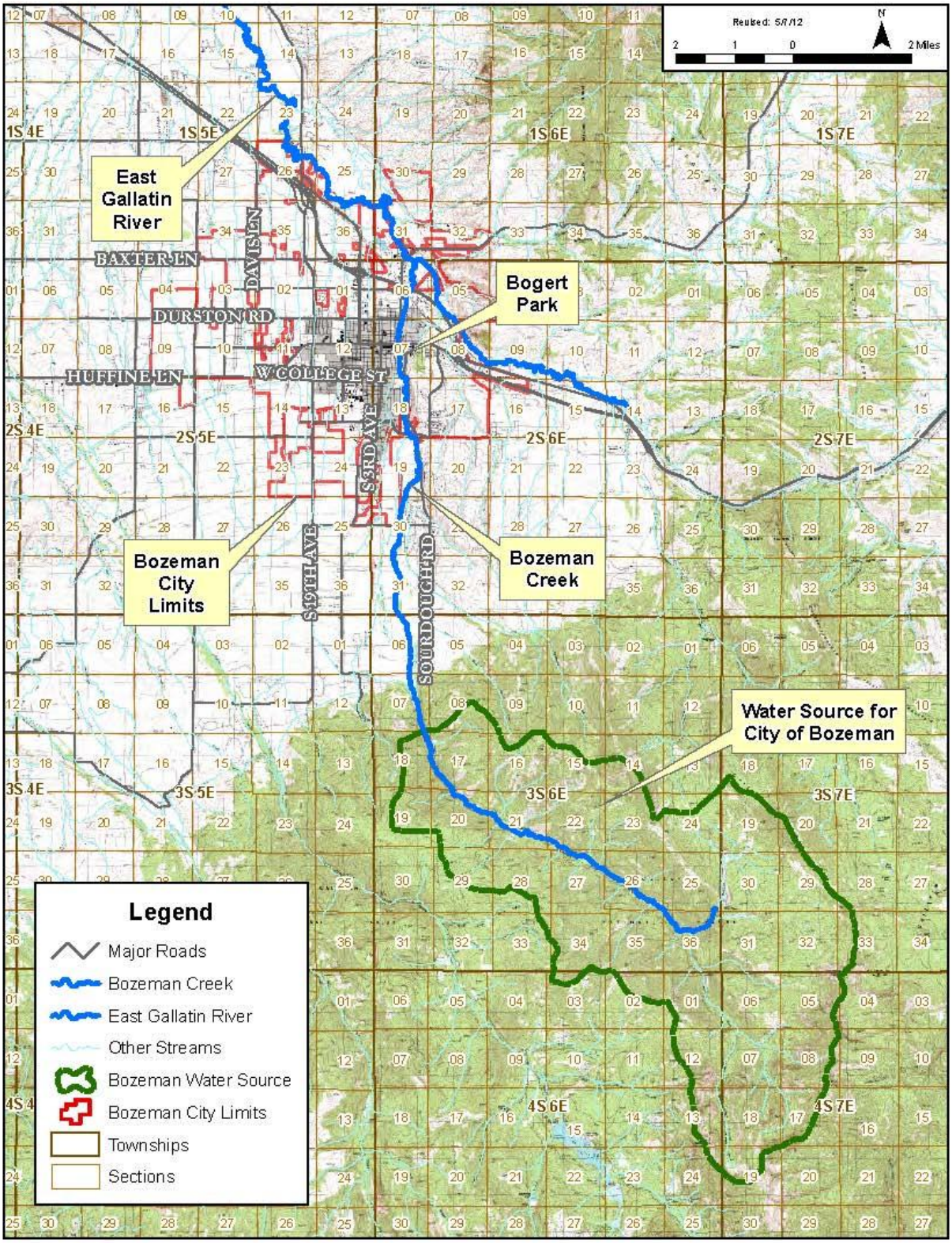
Design Information Guidelines for Application Submittal

For a detailed description of current and proposed project hydrology and morphology, along with design drawings, please refer to the Bozeman Creek Enhancement Project at Bogert Park, Preliminary Design Report, provided digitally to Mark Lere on 11/19/13. Pertinent excerpts are included below.

1. *Provide a narrative description of the present baseline conditions of the stream and riparian area. Provide a map showing the location of the proposed project. Identify stream type (ephemeral, intermittent, perennial) and stream classification (Rosgen or Montgomery-Buffington methodologies). Provide existing bank-full channel dimensions (width and depth; slope on larger scale projects). Provide photographic documentation of the existing channel, including a photograph of the existing typical channel substrate with an associated ruler for scale.*

Project Location




Revised: 5/7/12
N
2 1 0 2 Miles
East Gallatin River
Bogert Park
Bozeman City Limits
Bozeman Creek
Water Source for City of Bozeman
BAXTER LN
DAVIS LN
DURSTON RD
HUFFINE LN
W COLLEGE ST
S 3RD AVE
S 19TH AVE
SOURDOUGH RD
1S 4E
1S 5E
1S 6E
1S 7E
2S 4E
2S 5E
2S 6E
2S 7E
3S 4E
3S 5E
3S 6E
3S 7E
4S 6E
4S 7E
Legend
Major Roads
Bozeman Creek
East Gallatin River
Other Streams
Bozeman Water Source
Bozeman City Limits
Townships
Sections

Baseline Conditions

Stream channel

Data: Bozeman Creek morphology measurements through Bogert Park, hydrological and hydraulic analyses, property ownership survey and map.
Documentation: Preliminary Design Report (Confluence et al), Hydraulic Modeling Report (Allied Engineering), Bozeman Creek Enhancement Committee (BCEC) field reconnaissance notes.
Underlying causes: Channelization, inadequate facilities for park users to access the creek

Bozeman Creek long ago was channelized from Bogert Park downstream through much of the city to the north. This channelized condition has been maintained over the years to protect adjacent property and infrastructure. In Bogert Park, natural stream structure and function has been sacrificed in order to maximize park acreage in flat, grassy terrace.

The 3 ½ mile reach of Bozeman Creek from the city's jurisdictional boundary to just south of Bogert Park flows in a relatively unaltered state, though constrained in places by revetments. This reach flows across the same valley slope and over the same soils (alluvial fan deposits) as the reach from Bogert Park north to the East Gallatin River, yet the pattern of the two adjacent reaches is markedly different. The upstream reach exhibits a single-thread meandering pattern, with a sinuosity (channel length divided by valley length) of 1.4, as measured through two reference reaches. From Bogert downstream to the East Gallatin River, the creek has been highly channelized, with an overall sinuosity of 1.1. Through Bogert Park itself, the creek has been confined in a linear and entrenched channel along the extreme west end of the public property, with a sinuosity of 1.0. This channelization has increased the slope of Bozeman Creek through Bogert Park by about 40%, from an inferred pre-development slope of .8% to the existing condition in the park of 1.1%. Steepening the channel has increased shear stress and resulted in downcutting and entrenchment, severing the creek's access to its historic floodplain. Flood flows are prevented from spreading out, dissipating energy, dropping sediment, and recharging groundwater.

Channel banks typically rise 4 feet above bankfull elevation to meet the terrace elevation on both sides. Much of this rise is vertical and unstable. Hydraulic forces and trampling from park users has degraded and eroded much of the length of the bank. Of the 820 lineal feet of streambank in the project area, 325' feet of the west bank and 225' of the east bank shows evidence of significant erosion. The downstream 240' of the west bank has been armored with placed stone. Two areas along the east bank habitually have provided creek access to park users, and have been trampled and

denuded of vegetation. The creek banks in these areas are severely eroded and have receded as much as 12 feet. High flows in Spring, 2011 were observed causing a large swath of bank 4' deep to calve and wash away. This process will soon threaten a nearby cluster of 5 large, old growth cottonwood trees located at the edge of the high terrace. Soils lost from creek banks and eroded access sites wash downstream, exacerbating the creek's existing sediment impairment.

Aquatic habitat and populations

Data: Fish population counts, visual assessment of aquatic habitat, Wohlman pebble counts

Documentation: MT FWP reports; personal communications with Mike Vaughn, MT FWP Fisheries Biologist; 2004 Sourdough Creek Watershed Assessment

Underlying causes: Lack of hydraulic diversity, vegetation/cover, suitable substrates, and geomorphic features .

Aquatic habitat through Bogert Park is poor due to the lack of hydraulic diversity, vegetation and cover, suitable substrates, and geomorphic features that contribute to habitat for all stages of the life history of aquatic organisms. Bed materials consist of cobbles and coarse gravels, with pockets of sands and fine gravels in areas of lower energy. Much of the bed is immobile at normal spring flows, providing poor habitat for fish and macroinvertebrates. The riffle-pool structure that should be expected in this geomorphic setting is absent, replaced by a relatively featureless run. Hydraulic complexity is very low, with minimal channel curvature and few roughness elements such as larger rock or woody debris. Little cover is provided for fish by deep pools, overhanging vegetation, large woody debris or rock. Low flows in the summer are spread over the wide channel bottom; there is no low flow channel to concentrate summer flows nor pool refugia to cool temperatures.

In September of 2011, Montana Fish, Wildlife and Parks electrofished 400' of the creek through Bogert Park. They found 26 brown trout, mostly 10-12"; 4 rainbow trout, 1 Yellowstone cutthroat trout, mottled sculpins, and suckers. FWP staff concluded that the fish were relatively healthy, but their numbers and sizes were well below what a stream this size should be able to carry if it had better habitat. Older fish predominate, indicative of poor reproduction. Staff estimated that Bozeman Creek through the park may currently support only 25% or less of its potential for introduced trout (personal communication, Mike Vaughn, MT FWP Fisheries Biologist, April 2012).

Creek reaches above and below the urbanized section exhibit much better aquatic habitat and fish populations. In an upper watershed reach of Bozeman Creek in the national forest, over 200 rainbow and brook trout per 1000' were documented. The

downstream-most reach of Bozeman Creek, just upstream of the East Gallatin River, has a substantial population of large trout over 12", with good aquatic habitat provided by dense understory vegetation, a thriving beaver population and many deep pools.

Riparian vegetation
Data: Age, species and condition of woody plants in Bogert Park riparian zone
Documentation: BCEC vegetation report, photos.
Underlying causes: Channelization, loss of floodplain benches, past preference of property owners for grassy areas over woody vegetation.

The riparian zone through Bogert Park is very thin, consisting primarily of an intermittent single row of cottonwood trees, with occasional chokecherry shrub patches. A few blue spruce and green ash trees and some ornamental shrubs are the only other near-channel vegetation. Many of the cottonwood trees are over 12", with about 1/3 of the trees pole-sized at 5" – 12". A cluster of five very large cottonwoods, in excess of 100 years old, stands in close proximity to the highest use area of the creek. These trees may be decaying and posing a safety risk to the recreating public. There is a near-total absence of cottonwood or willow seedlings or saplings, attributable to the lack of low-elevation surfaces where seedlings would have ready access to groundwater. Almost all of the riparian trees are growing on the steep bank slopes below terrace level. Other than the chokecherry patches, there is no understory of woody or herbaceous vegetation.

The creek corridor through Bogert Park is not competent to detain and filter floodwaters. Immediately adjacent the creek channel, Bogert Park is maintained in turfgrass, with fertilizer and pesticide applications and extensive use by human and canine park visitors. Similar problems exist on the privately owned west side of the creek. The creek's thin riparian zone cannot do an adequate job of filtering pollutants from runoff entering the creek from the terraces on either side. Hence, water quality impacts to the creek marginally increase through the Bogert reach.

Wildlife habitat provided by Bogert's riparian vegetation is poor, and attendant use by wildlife is far below its potential. There has been no formal study of wildlife populations or habitat in Bogert, but wildlife sightings mostly are limited to birds and squirrels.

Stream type
Perennial, Rosgen B3/B4

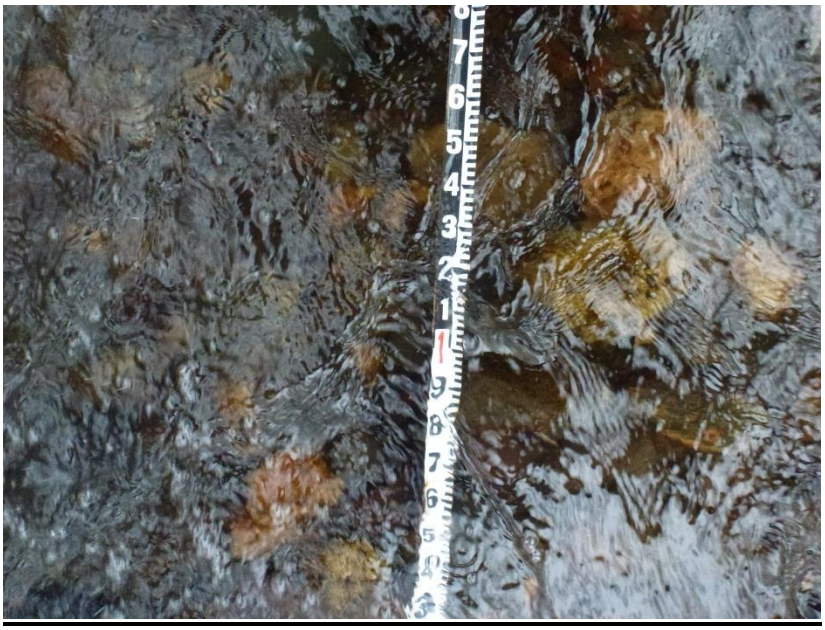
Channel dimensions

Existing and proposed cross section dimensions for reconstructed segment of Bozeman Creek through Bogert Park (from the Preliminary Design Report):

Chanel Segment	Parameter	Reach Average (ft)	Reach Minimum (ft)	Reach Maximum (ft)
Existing channel	XS Bankfull width	28.5	22	35
	XS Mean bankfull depth	1.5	1.3	1.7
	XS W/D ratio	19.5	12.5	26.6
Proposed riffles in reconstructed channel	XS Bankfull width	28	25	31
	XS Mean bankfull depth	1.5	1.4	1.6
	XS Max bankfull depth	1.75	1.6	1.9
	XS W/D ratio	19	15.2	21.6
Proposed pools in reconstructed channel	XS Bankfull width	25	23	27
	XS Mean bankfull depth	2.1	2.0	2.2
	XS Max bankfull depth	3.2	3.1	3.5
	XS W/D ratio	12.1	13.3	10.7

Channel slope: 1.1%

Sinuosity: 1.0



Typical channel substrate

Vertical banks and thin vegetation, Bozeman Creek in Bogert Park

Severe bank erosion, Bozeman Creek in Bogert Park

2. Identify the cause(s) of existing impairments on the proposed project reach and describe how the project would restore appropriate conditions.

This reach of Bozeman Creek was channelized not long after the area was settled around 1880. Straightening, shortening and steepening this reach led to channel incision and loss of floodplain connectivity. Development of concrete culverts taking the creek's flow beneath streets upstream and downstream of the park maintains the existing creekbed elevation. Flood flows combined with bank trampling by park users has created steep, bare-soiled, unstable streambanks. The minimal riparian vegetation does a poor job of stabilizing banks and filtering pollutants from park runoff, and contributes little to aquatic habitat. This enhancement project will correct this degraded condition by reconstructing channel and floodplain with a sustainable and ecologically productive morphology, creating the geomorphic and hydraulic diversity necessary for good aquatic habitat, and enlarging/improving the riparian zone.

3. Provide an estimate of design discharge and note the method(s) of estimation. If the proposed design is based on a reference reach, provide specific descriptive information (channel type, bank-full width, and bank-full depth; slope on larger scale projects) and explain applicability to the proposed project reach. Identify the location of any or all reference reaches on a map. Provide photographic documentation of the reference channel.

The following narratives on 'design discharge' and 'proposed design' have been excerpted from the Preliminary Design Report.

Design discharge

Bozeman Creek has almost no available gage data records available to assist in predicting typical flood discharges. Regional regression equations developed by the USGS (Johnson and Parrett 2004) are an acceptable hydrologic analysis method as long as the basin characteristics of the project site are within the range used to derive the equations. Bozeman Creek at Bogert Park falls within the acceptable range of values for the regional regression equations.

The following table provides discharges at various return intervals for Bozeman Creek at Bogert Park as calculated with the regression equations:

Bozeman Creek at Bogert Park									
Upper Yellowstone Region Drainage Area >6000' = 32.6 sq. mi (63.1%) Drainage Area <6000' = 19 sq. mi (36.9%) Total Drainage Area = 51.6 sq. mi	Return Interval (yr)	2	5	10	25	50	100	200	500
	Q (cfs)	233	419	574	803	994	1198	1414	1732

An independent hydrologic analysis was performed by Allied Engineering to develop a hydraulic model of Bozeman Creek through downtown Bozeman. The surrogate bankfull flow in that report was derived using data from three other gaged streams in the Gallatin Valley, an estimate of the natural slope of Bozeman Creek prior to it being channelized, and channel widths measured from LiDAR data and high resolution aerial photos. The method Allied used may slightly underestimate bankfull flows at Bogert Park, as the estimated flow of 208 cfs was partially based on an analysis of existing bankfull channel widths 3.5-4.5 miles upstream.

To more accurately determine the extent, dimensions, and bankfull discharge of the existing channel through the park, we surveyed five cross-sections through Bozeman Creek at Bogert Park. An at-a-station hydraulic program (WinXSPro) was used to determine the stage, cross-sectional area, and top-width of the existing channel at various discharges. The average channel width in Bogert Park during a 2-year discharge of 233 cfs (as estimated by regional regression equations) was 28.5 feet.

A bankfull design discharge of 233 cfs was selected for preliminary design based on the regional regression equations, a review of the hydrologic analysis performed by Allied Engineering, at-a-station hydraulic modeling of surveyed cross sections in the Bogert Park reach, and best professional judgment. The bankfull design discharge of 233 cfs was used to determine preliminary dimensions of the proposed bankfull channel and the corresponding elevation of the proposed inset floodplain.

Proposed design

For the purposes of preliminary design, a bankfull channel template was derived by surveying five cross sections of the existing channel, then running an at-a-station hydraulic model at each cross section, and determining channel dimensions at a discharge of 233 cfs. This analysis was essentially a reference reach approach that used the existing channel as an internal reference. Although the existing channel has been heavily manipulated, it was suitable for developing preliminary design dimensions for the channel segment to be reconstructed, including bankfull width, maximum depth, mean depth, and width/depth ratio.

All natural stream channels exhibit variability in width and depth as sediment erodes and deposits within the channel and floodplain. Incorporating variability in stream

channel increases habitat complexity in the form of riffles, pools, variable flow velocities, and substrate sizes. Each of these habitat variables contributes to the biological integrity and diversity of fish and other aquatic life. Habitat diversity was incorporated into the design of Bozeman Creek by including variable channel widths and two meander sequences, which include riffle and pool components.

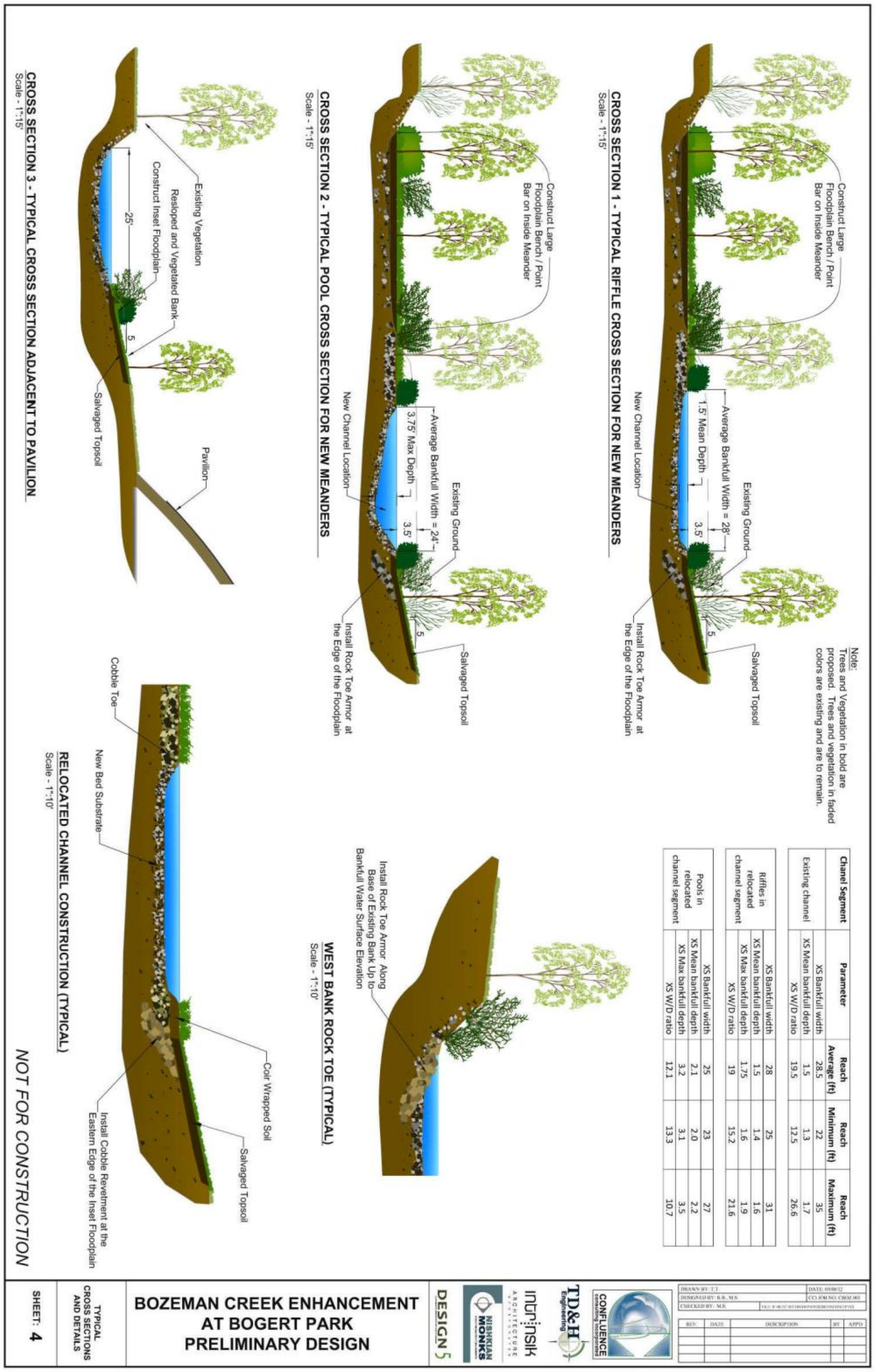
The creation of meander bends within the park provides an excellent opportunity for diversifying stream habitat. The existing channel is straight and is considerably more simplified in habitat complexity than a more sinuous and naturally meandering channel. New meanders proposed along Bozeman Creek will be designed with bed and bank features suitable for pool and riffle formation to provide additional habitat complexity for fish, macroinvertebrates, and other aquatic life in the creek. Riffle features will be designed to allow for fish passage during periods of base flows. Pool features will be designed to provide resting and feeding areas for adult fish.

It is important to note that the hydrologic analyses performed during preliminary design provide only partially adequate input as to what the geomorphically relevant bankfull discharge should be at the project site. Final design efforts will include measuring discharge during a bankfull event at reference locations where floodplain connectivity is unaffected by channel alterations. A proper reference reach for Bozeman Creek at Bogert Park is not available due to urbanization and channel modifications in the vicinity of the project. A more appropriate location to measure bankfull discharges would be in Bozeman Creek and Matthew Bird Creek (a major tributary) approximately 1000’ upstream of the project site where natural floodplain characteristics exist. The bankfull discharge would be the sum of the estimated bankfull discharges at the two sites.

The bankfull discharge determined during final design will be used as a hydraulic modeling and sediment transport input to develop the final suite of channel cross section dimensions, refining the preliminary analyses. Channel dimensions will be designed to convey the established bankfull discharge while providing for overbank flow at higher discharges. Sediment transport and incipient motion analyses will ensure that riffle and pool bed materials will only mobilize at the discharges specified in the design criteria, and that the channel neither aggrades nor degrades.

4. Provide a plan view drawing for the entire reach, showing placement of all structures and proposed treatments (including fencing).

5. Provide typical drawings for all proposed structures.


CROSS SECTION 1 - TYPICAL RIFFLE CROSS SECTION FOR NEW MEANDERS
Scale - 1":15'
Construct Large Floodplain Bench / Point Bar on Inside Meander
Average Bankfull Width = 28'
1.5' Mean Depth
3.5'
Existing Ground
New Channel Location
Salvaged Topsoil
Install Rock Toe Armor at the Edge of the Floodplain
5
Note:
Trees and Vegetation in bold are proposed. Trees and vegetation in faded colors are existing and are to remain.
CROSS SECTION 2 - TYPICAL POOL CROSS SECTION FOR NEW MEANDERS
Scale - 1":15'
Construct Large Floodplain Bench / Point Bar on Inside Meander
Average Bankfull Width = 24'
3.75' Max Depth
3.5'
Existing Ground
New Channel Location
Salvaged Topsoil
Install Rock Toe Armor at the Edge of the Floodplain
5
CROSS SECTION 3 - TYPICAL CROSS SECTION ADJACENT TO PAVILION
Scale - 1":15'
Existing Vegetation
Resloped and Vegetated Bank
Construct Inset Floodplain
25'
5
Salvaged Topsoil
Pavilion
WEST BANK ROCK TOE (TYPICAL)
Scale - 1":10'
Install Rock Toe Armor Along Base of Existing Bank Up to Bankfull Water Surface Elevation
RELOCATED CHANNEL CONSTRUCTION (TYPICAL)
Scale - 1":10'
Cobble Toe
New Bed Substrate
Coir Wrapped Soil
Salvaged Topsoil
Install Cobble Revetment at the Eastern Edge of the Inset Floodplain
NOT FOR CONSTRUCTION
BOZEMAN CREEK ENHANCEMENT AT BOGERT PARK PRELIMINARY DESIGN
TYPICAL CROSS SECTIONS AND DETAILS
SHEET: 4
DESIGN 5
CONFLUENCE
TD&H Engineering
intrinsik
DRAWN BY: T.T.
DESIGNED BY: B.R., M.S.
CHECKED BY: M.S.
REV.
DATE
DESCRIPTION
BY
APPD

Chanel Segment	Parameter	Reach Average (ft)	Reach Minimum (ft)	Reach Maximum (ft)
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	XS Mean bankfull depth	1.5	1.4	1.6
	XS Max bankfull depth	1.75	1.6	1.9
	XS W/D ratio	19	15.2	21.6
Pools in relocated channel segment	XS Bankfull width	25	23	27
	XS Mean bankfull depth	2.1	2.0	2.2
	XS Max bankfull depth	3.2	3.1	3.5
	XS W/D ratio	12.1	13.3	10.7

6. Describe proposed and future land use activities within adjacent riparian areas

Bogert Park will continue to be a community park owned and managed by the City of Bozeman for recreational uses. The riparian area will be used by park visitors for fishing, bird-watching, and enjoying the sights and sounds of nature in the city.